Empty Container Management—The Case of Hinterland

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Abstract The empty container management is one of the most popular problems in shipping. The container repositioning is very expensive and shippers cannot generate profit with it, so it is very important for shippers to have an efficient container management. This paper discusses the problem of repositioning empty containers in a cheap way and it shows up a possible optimization for the problem. First, the paper introduces the subject of the empty container management. This section is followed by a problem description and a modified Inland Empty Container Depot (IDEC) model based on Mittal, which solves the container problem. Afterwards, there is a description of the further modification of the model for the empty container management problem in hinterland, which is based on the modified IDEC. This model additionally considers the container transportation by barge and train, while the IDEC only uses the truck. In the last chapter of the paper, some possible results are presented.

Keywords Container management · Empty container repositioning · Inland depot · Modified IDEC · Hinterland

Introduction

The objective of empty container management is to make containers available for reload while minimizing transport costs and maximizing benefits (Furió et al. 2009). Empty transports are often unavoidable, because normally the place of container discharge and the place of loading are not identical. Hence, containers have to be repositioned. Repositioning can be conducted on a local, interregional, and global level (Hautau et al. 2008). The whole process of container logistics starts

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H. Kotzab et al. (eds.), *Dynamics in Logistics*,
Lecture Notes in Logistics, DOI 10.1007/978-3-319-23512-7_15

with discharging at importers place and ends upon positioning boxes at exporters' location (Furió et al. 2009).

It is very important to have an efficient empty container management for shippers, because the transportation of empty boxes causes substantial costs, which are nearly as high as the transportation of full containers. The difference between these sorts of transportation is, that shippers can generate proceeds when they deliver a full container, but they cannot generate any proceeds by repositioning empty containers (Exler 1996). Drewry Shipping Consultants estimates global costs incurred by repositioning empty containers for 2010 to 34.8 billion US-Dollar, which is an increase of 3.5 billion US-Dollar according to 2009 (Drewry Shipping Consultants 2011). Of this amount, 11.4 billion US-Dollars are related to land transport and 23.4 billion US-Dollars to sea transport (Drewry Shipping Consultants 2011). Each repositioning amounts to a total of 400 US-Dollars per container. Overall, the proportion of empty transportation amounted to 21.3 % at sea (Drewry Shipping Consultants 2011) and nearly 40 % at land (Konings 2005).

The global container traffic has more than doubled within the past decade. In the year 2000, there was a traffic of 236.7 million TEU and according to 2010, there was 548.5 million TEU. The percentage of empty containers in the total container amount has only minor fluctuations and conducts in the past five years an average of 21.3 % (Drewry Shipping Consultants 2011).

It is assumed that a container only spends 20 % of its lifecycle at sea and 56 % it is empty, i.e., it is under repair, in maintenance, or in transit (De Brito and Konings 2008). This high unproductive part has to be reduced in order to make the use of containers more efficient. Apart from this, there are also 1.5–2.5 million TEU stored in the hinterland of seaports so that there is a high space requirement, resulting in a shortage of storage areas in ports (Vojdani and Lootz 2011). "For the benefit of port operators, shippers and carriers, the number of empty boxes sitting at the terminals should ideally be nil or very few" (Boile et al. 2004).

Conception of a Mathematical Model

One possible solution of the empty container management is presented by Mittal in her dissertation. She developed a mathematical model, which minimizes the total transport costs and adds additional space for storing containers in the hinterland, by opening new depots next to customer destinations (Mittal 2008). The model is formulated as "an inventory-based capacitated depot location problem under deterministic (…) demand patterns" (Mittal 2008) with a planning horizon of 10 years. In this section, the modified Inland Empty Container Depot (IDEC), which bases on Mittals model, will be presented. The difference to Mittals model is that there is a planning horizon of one year and only one shipper and one depot operator are regarded. In addition some variables are doped off and some variables, like the dummy variable z_{ik} is introduced in the constraints.

Before the objective function can be presented, some assumptions have to be introduced. The first one is that there is no direct transport between an importer and an exporter and there is also no transport between the depots in a region. Furthermore, there is a linear cost structure. The operating costs at each depot are equal. A shipper can get a container out of a depot, if it is assigned to it. Each exporter and importer is also assigned to only one depot. Variables, which are not in the formulation have to be zero.

The objective function is the following:

$$Z = \min \sum_{i \in F} f_i * y_i + \sum_j \sum_i \left(S_j * x_{ji} * c_{ji}\right) + \sum_i \sum_k \left(D_k * x_{ik} * c_{ik}\right) + \sum_i \sum_h \left(x_{ih} * c_{ih}\right) + \sum_h \sum_i \left(x_{hi} * c_{hi}\right)$$

The first term presents the fix costs for opening a depot. The following terms two to five stand for transportation costs within the network. For example, the second and the third term are transportation costs between importer and depot, respectively exporter and depot. At fourth and fifth place, the costs between port and depot or rather depot and port are shown. Beside the objective function, there are some constraints. First of all, there are 4 constraints, which are presenting the demand and supply of empty containers by the port, the exporter, and the importer. Additionally, there is another constrain, which describes the initial inventory of containers in a depot. A sixth constrain keeps a depot open, when a volume of containers arrives, furthermore it ensures that the capacity of the depot would not be passed. In a seventh constraint it is ensured that depots, which already exist in the region, will stay open. In addition, there also will be needed 4 constraints, which define the variables of the port, the exporters, the importers, the depots, and the depot inventory as non-negative. At least, there are two last constraints, which are integrality constraints (Mittal 2008). Beside these constraints, there are some totally new constraints, which Mittal did not have and which are not modified. There are two constraints, which ensure that the whole transport volume uses the same link. Another two constraints assigns the importers and exporters to only one depot, when it is open. Because of this simple assignment two dummy variables have to be introduced and two constraints defines this as binary.

Further Model Development

In order to develop a new model from the presented relationships above, the following steps have to be done: As a first step to solve the empty container problem in the hinterland, the literature should be reviewed in order to seek out existing solutions. After that in a second step, the network of waterways and rail in Germany should be analyzed in order to get rid of free potentials in intermodal transportation. As a third part, a mathematical model should be setup. For this model, the modified

IDEC will be modified by expending it about intermodal transportation. That means the model will regard the transportation by truck, by train, and by barge. Also the assumptions and the constraints have to be modified, i.e., a new variable for train and barge have to be introduced and there have to be a constraint for the cost structure for all types of transportation. The purpose of IDEC and the modified IDEC is to reduce transportation costs by building up depots in inland, and in addition to create new storage capacity out of the ports. Another and or additional idea is to integrate the model of Dry Ports in the modified IDEC and to generate a hub and spoke network between the port, the importers, the exporters, and the terminals. In conclusion, the modified model will be tested in a case study. This study will focus on the port of Bremerhaven with its hinterland. The hinterland will be represented by Germany. All in all I will focus on hinterland transportation and regional repositioning.

Expected Results

After implementing the modified model, the total transportation costs should be reduced by avoiding preventable empty trips. In total, the model should be very realistic and it should be able to implement the intermodal transport in empty container repositioning. Ideally, the modal split will be equal in all the types of transportation, by truck, by train, and by barge.

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